PATENT SPECIFICATION

(11) 1 584 131

(21) Application No. 16734/78 (22) Filed 27 April 1978
(31) Convention Application No. 52/050 076
(32) Filed 30 April 1977 in
(33) Japan (JP)
(44) Complete Specification published 4 Feb. 1981
(51) INT CL³ B21C 23/24, 25/06//27/02, 33/00, 33/02
(52) Index at acceptance B3P 10X 13 16C 4A 4B 7E

(72) Inventors MASAHIRO NAGAI and YASUHIKO MIYAKE

(19) THE PATENT OFFICE LONDON

(54) METHOD AND APPARATUS FOR THE MANUFACTURE OF A COMPOSITE METAL WIRE

(71) We, HITACHI CABLE, LTD., a Company organised under the laws of Japan, of 1—2, Marunouchi 2-chome, Chiyoda-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method and apparatus for the manufacture of a composite metal wire having a core metal wire and a coating metal layer extruded therearound which is different in material from the core metal wire.

Conventionally, a composite metal wire has been manufactured according to methods well known to those skilled in the art and put into a practical use for many purposes. In one of the typical methods, a composite metal wire is manufactured with use of composite billets. Such a billet has a construction of an inner core metal and an outer coating metal which are concentrically postiioned. In another method, a composite metal wire is manufactured with the extrusion of a coating metal around a running core wire. In the former method wherein the composite billet is used, an extruder or a rolling apparatus has been adopted.

In such a method of manufacturing a composite metal wire, it is desirable that a composite metal wire is continuously manufactured in an indefinite length and a uniform quality is obtained along the entire length thereof.

In a method of using a composite billet, however, such a billet proves itself a limitation in regard to the volume thereof so that it is definitely impossible to manufacture a composite metal wire of an indefinite length. For this reason, a predetermined number of the composite billets must be connected one after another in every stroke of extrusion to provide a desired length of a composite metal wire. However, such a connection of composite billets is extremely difficult during the manufacture thereof. Accordingly, the manufacturing operation is heavily interrupted by this connection of composite billets. This results in a lower productivity in the manufacture of a composite metal wire. Further, even if a composite metal wire of an infinite length can be manufactured in the method as set forth above, it has been considered extremely difficult to provide a composite metal wire with a uniform quality along the entire length thereof.

On the other hand, a coating metal also proves itself a limitation in regard to the volume thereof even in a method of extruding a coating metal layer on a core wire although the core wire is easily available in an indefinite length. Accordingly, it is absolutely required that the coating metal is recharged into an extruder at every stroke of extrusion to provide a composite metal wire with such a length. However, a lower productivity also results from the interruption of the manufacturing operation in accordance with the recharging process thereof. In this method, especially, the so-called "stop-mark" is often observed on the products since it is difficult to uniformly control the condition of extruding a coating metal layer in different strokes of extrusion.

As explained above, the disadvantages in the methods of using a composite billet and of extruding a coating metal layer are that a composite metal wire is impossible to be continuously manufactured and irregularities on a material used are found longitudinally on the products. Especially, it has been regarded as a great problem that such irregularities are produced due to the above mentioned reason in the manufacture of an electrical conducting wire such as an aluminium-clad steel wire (aluminium coated steel wire).

According to one aspect of the present invention, there is provided an improved method of manufacturing a composite metal wire including a metal core wire surrounded by a coating metal of a material different from said metal core wire, said method comprising:

providing a rotary wheel having therein a peripheral groove;

providing a fixed shoe block having a fitting surface cooperating with a circumfer-

ential portion of said groove to define therewith a narrow passageway having an inlet end and an outlet end, a fixed stopper portion fitting in said groove to entirely close said passageway and to define said outlet end thereof, and a covering chamber communicating with said outlet end of said passageway and having a nipple for guiding a metal core wire and a die for defining the outer cross-section of a composite metal wire;

feeding coating metal into said inlet end of said passageway, while rotating said rotary wheel in a direction toward said outlet end of said passageway;

subjecting said coating metal within said passageway to plastic deformation due to oppositely directed frictional forces including a greater friction force from the surfaces of said wheel defining said groove and a lesser friction force from said fitting surface of said fixed shoe block;

positively carrying said coating metal through said passageway by said greater friction force and causing said coating metal to collide with said fixed stopper portion; thereby imparting an extrusion pressure to said coating metal;

passing a metal core wire into said nipple and through said covering chamber; and

due to said extrusion pressure, passing said coating metal into said chamber, thus filling said chamber with said coating metal, covering said metal core wire with said coating metal to form a bond therebetween, and extruding through said die said metal core wire covered with said coating metal as a composite metal wire.

The invention also provides an apparatus for manufacturing a composite metal wire including a metal core wire surrounded by a coating metal of a material different from said metal core wire, said apparatus comprising:

a rotary wheel having therein a peripheral groove a fixed shoe block having a fitting surface cooperating with a circumferential portion of said groove to define therewith a narrow passageway having an inlet end and an outlet end, a fixed stopper portion fitting in said groove to entirely close said passageway and to define said outlet end thereof, and a covering chamber communicating with said outlet end of said passageway having a nipple for guiding a metal core wire and a die for defining the outer cross-section of a composite metal wire, whereby:—

on feeding coating metal into said inlet end of said passageway, while rotating said rotary wheel in a direction toward said outlet end of said passageway, said coating metal is subjected within said passageway to plastic deformation due to oppositely directed frictional forces including a greater friction force from the surfaces of said wheel defining said groove and a lesser friction force from said fitting surface of said fixed shoe block, said coating metal is positively carried through said passageway by said greater friction force and causing said coating metal to collide with said fixed stopper portion, thereby imparting an extrusion pressure to said coating metal, and, due to said extrusion pressure, said coating metal is passed into said chamber, thus filling said chamber with said coating metal;

and, on passing the metal core wire into said nipple and through said covering chamber said metal core wire is covered with said coating metal to form a bond therebetween, and can be extruded through said die said metal core wire covered with said coating metal as a composite metal wire.

According to a feature of the present invention, a core metal wire is harder in material than a coating metal in the construction of a composite metal wire. For instance, metals such as steel, copper, aluminium or alloys thereof may be used as materials of the core metal wire.

On the other hand, the coating metal may be less resistance to deformation than the core metal wire. For instance, metals such as zinc, lead, tin or alloys thereof, in addition to the metals for the core metal wire, may be used as materials of the coating metal in the combination of two metals as set forth above. In addition, a coating metal may be fed in the form of a wire member, metal powder or liquid metal in accordance with a specified manufacturing condition of a composite metal wire.

According further to the present invention, the following composite metal wires can be effectively manufactured, that is, for instance, aluminium-clad steel wire (aluminium coated steel wire), aluminium-clad copper wire (aluminium coated copper wire), copper-clad steel wire (copper coated steel wire), lead-clad steel wire (lead coated steel wire), lead-clad aluminium wire (lead coated aluminium wire).

Other objects and aspects of the invention will become apparent from the following description of preferred embodiments with reference to the accompanying drawings in which:

Fig. 1 is a sectional view illustrating apparatus for manufacturing a composite metal wire embodying the present invention,

Fig. 2 is a sectional view taken along the line II—II of Fig. 1,

Fig. 3 is a sectional view illustrating apparatus for manufacturing a composite metal wire in another manner embodying the present invention,

Fig. 4 is a sectional view taken along the line IV—IV of Fig. 3, and

Fig. 5 is a sectional view taken along the line V—V of Fig. 3.

With reference to Figs. 1 and 2, there is shown apparatus for manufacturing a com-

posite metal wire according to the present invention. A rotatory wheel 10 is provided with a circumferential groove 12 on the outer edge having an approximately U shaped cross section. The rotatory wheel 10 is mounted on a drive shaft 11 to allow the rotation thereof in a predetermined direction. A shoe block 13 is fixed to a base (not shown) so as to keep a close fit to the rotatory wheel 10. A narrow passageway 15 is defined for feeding an aluminium bar 14 thereinto between the circumferential groove 12 of the rotatory wheel 10 and the fitting surface of the fixed shoe block 13. This passageway 15 is considered to have a container-like function for the aluminium bar 14 and is shaped as having a cross sectional area decreased halfway and increased therefrom to the back thereof as illustrated by d1 and d2 designating a large and small portions of the cross sectional area respectively in Fig. 1.

A covering room or chamber 18 is installed at the back of the passageway 15 and is provided with a die 16 and a nipple 17 at the front and rear portions respectively. A steel wire 19 is introduced as a core metal wire through the die 16 and nipple 17 into the covering room 18. A stopper 22 is positioned at the end of the passageway 15 and a portion 20 having a decreased cross sectional area is installed above the stopper 22.

The cross sectional area of the covering room 18 is designed to be larger than that of the passageway 15 and that of the area decreased portion 20. The presence of the covering room 18 having a larger area the the area of decreased portion 20 allows the pressure of extrusion necessary for the manufacture of a composite metal wire to remain stable during the manufacturing operation as set forth in detail hereinafter.

The stopper 22 is adapted to close the end of the passageway 15.

In operation, the extrusion of a composite metal wire is effected with the rotation of the wheel 10 in the arrow direction and feeding of the aluminium bar 14 into the passageway 15. The aluminium bar 14 is subjected to the contacting frictional resistance against the groove 12 as the rotatory wheel 10 rotates so that the aluminium bar 14 is carried by frictional drag towards the back of the passageway 15 and passes into the covering room 18 in a fluid condition. The fluid aluminium 21 surrounds the steel wire 19 in the covering room 18 so that an aluminium-clad steel wire 22 is extruded through the die 16 of the extruder.

In Figs. 3 to 5, there is shown apparatus for manufacturing a composite metal wire called "two wheel system" of another embodiment according to the present invention.

Two rotary wheels 10 and 10a are symmetrically mounted an drive shafts 11 and 11a respectively.The rotary wheels 10 and 10a are provided on the outer edge with circumferential grooves 12 and 12a having a U shaped cross section respectively. A common shoe block 13 is fixed to a base (not shown) so as to keep a close fit to the rotatory wheels 10 and 10a. Narrow passageways 15 and 15a are defined for feeding aluminium bars 14 and 14a thereinto between the circumferential grooves 12 and 12a of the rotatory wheels 10 and 10a and the fitting surfaces of the fixed shoe block 13 respectively.

Each of the passageways 15 and 15a is shaped as having a cross sectional area decreased halfway and increased therefrom to the back thereof as fully explained in the former embodiment.

A covering room 18 is installed at the respective backs of the passageways 15 and 15a and is provided with a die 16 and a nipple 17 at the front and rear portions respectively. A steel wire 19 is introduced into the covering room 18. Stoppers 22 and 22a are positioned to close the respective ends of the passageways 15 and 15a.

In the two wheel system of this embodiment according to the present invention, each of the aluminium bars 14 and 14a is of 8mm in diameter and steel wire 19 is of 2.6mm in diameter.

The driving force of the rotatory wheels 10 and 10a is 30 HP equally and the revolution number thereof is 10 r.p.m. The configuration of the circumferential grooves 12 and 12a is of a rectangle of 8mm in width so that the cross sectional area thereof is 64mm^2. Further, the cross sectional area of the covering room 18 is 200mm^2 while that of area decreased portions 20 and 20a is 50mm^2.

The aluminium bars 14 and 14a are fed into the passageways 15 and 15a respectively after being subjected to a preliminary heating up to 300—450°C. The extrusion of a composite metal wire is effected by the pressure of extrusion of 15—40kg/mm^2 in the covering room 18. The steel wire 19 is preliminarily heated up to 250—350°C and is subjected to a forward traction force of 150—300 kg for the extrusion of the composite metal wire.

In case of manufacturing an aluminium-clad steel wire 23, the speed of extrusion is 150 m/min. The outer diameter of the aluminium-clad steel wire 23 is 3.2mm while the thickness of the coating aluminium is 0.3mm. As set forth above, the cross sectional area of the covering room 18 is larger than that of the passageways 15 and 15a.

This allows the sufficient quantity of the fluid aluminium contained in the covering room 18 to accomodate a minute fluctuation on the pressure of extrusion by the viscosity thereof even if such a fluctuation occurs for the aluminium bars 14 and 14a in the passageways 15 and 15a. Accordingly, the pressure

of extrusion is always kept stable when the coating aluminium 21 is metallurgically bonded to the steel wire 19. The decreased area portions 20 and 20a are positioned between the covering room 18 and the passageways 15 and 15a respectively. This prevents the fluid aluminium 21 from reversely flowing into the passageways 15 and 15a when the pressure of extrusion is extremely decreased due to the fluctuation of the contacting frictional resistance (frictional drag) in the passageways 15 and 15a. Accordingly, both the covering room 18 of a larger cross sectional area and the decreased area portions 20 and 20a serve the purpose of stabilizing the pressure of extrusion. The rotatory wheel 10 is provided with a fitting step portion 25 while the fixed shoe block 13 is provided with two fitting step portions 25a at both sides of the groove as shown in Fig. 5. Accordingly, the rotatory wheel 10 faces the fixed shoe block 13 with more than two fitting surfaces. Further, the fixed shoe block 13 is provided with a pair of shallow grooves 26 between the two fitting surfaces so that splinters of a coating metal 14 are easily set free even if they are produced.

Although the occurence of such splinters can be decreased to some extent by the close fit of the step portions 25 and 25a, it is very difficult to perfectly prevent the occurence of splinters. The shallow grooves 26 serve the purpose of suppressing the growth of such splinters due to the fact that the increase of pressure is avoided with the release thereof into the shallow grooves 26. Especially, it is ascertained that the occurence of splinters is remarkable near the portion of the stoppers 22 and 22a. However, splinters of a material to be carried can be easily set free because the stoppers 22 and 22a are designed to have side surfaces fitting into the grooves 12 and 12a which are provided with freeing surfaces respectively.

As set forth above, the various means are adapted to suppress the disadvantage of splinters so that no difficulty can be found even in the occurence of splinters in this embodiment according to the present invention. Further, such means for coping with the problem of splinters results in less consumption of power as a whole. Accordingly, this makes a big contribution to a practical use of the present invention.

The change of cross sectional area for the passageways 15 and 15a serves the purpose of not only producing the frictional drag necessary for the pressure of extrusion but also decreasing the frictional drag which is the cause of the consumption of power.

There is expected the following advantages in the above mentioned embodiment of the two wheel system in regard to the manufacture of a composite metal wire as compared to the former embodiment of a single wheel system.

One advantage is that less power is necessary to drive the rotatory wheels 10 and 10a and the ratio of extrusion can be larger so that the thickness of an extruded coating metal can be freely changed with in a broader range.

Another advantage is that the flows of an extruded coating metal are well balanced dynamically at the opposite entrances of the covering room 18 so that the uniformity is obtained in the bonding between a core metal wire and a coating metal and the uneven thickness of a coating metal layer hardly occurs. Further, the apparatus of the two wheel system is stable mechanic-dynamically so that there are expected less possibility of breakdown and an excellent durability.

It goes without saying that it is possible to increase the number of rotatory wheels other than two wheel system in the present invention. For instance, it is considered in a practical use that three wheels may be installed at angles of 120° degress to each other and four wheels may be installed at angles of 90°.

As fully explained in the above mentioned embodiments, there is no limitation on the length and volume for materials of a core metal and a coating metal and the manufacture of a composite metal wire can be continuously performed in an indefinite length thereof so that the productivity thereof is improved and an excellent product can be obtained without any irregularity of materials.

WHAT WE CLAIM IS:—

1. A method of manufacturing a composite metal wire including a metal core wire surrounded by a coating metal of a material different from said metal core wire, said method comprising:

providing a rotary wheel having therein a peripheral groove;

providing a fixed shoe block having a fitting surface cooperating with a circumferential portion of said groove to define therewith a narrow passageway having an inlet end and an oulet end, a fixed stopper portion fitting in said groove to entirely close said passageway and to define said outlet end thereof, and a covering chamber communicating with said outlet end of said passageway and having a nipple for guiding a metal core wire and a die for defining the outer cross-section of a composite metal wire;

feeding coating metal into said inlet end of said passageway, while rotating said rotary wheel in a direction toward said outlet end of said passageway;

subjecting said coating metal within said passageway to plastic deformation due to op-

positely directed frictional forces including a greater friction force from the surfaces of said wheel defining said groove and a lesser friction force from said fitting surface of said fixed shoe block;

positively carrying said coating metal through said passageway by said greater friction force and causing said coating metal to collide with said fixed stopper portion, thereby imparting an extrusion pressure to said coating metal;

passing a metal core wire into said nipple and through covering chamber; and

due to said extrusion pressure, passing said coating metal into said chamber, thus filling said chamber with said coating metal, covering said metal core wire with said coating metal to form a bond therebetween, and extruding through said die said metal core wire covered with said coating metal as a composite metal wire.

2. A method according to claim 1, wherein said step of feeding comprises feeding coating metal in wire form into said inlet end of said passageway.

3. A method according to claim 1, wherein said step of feeding comprises feeding coating metal in powder form into said inlet end of said passageway.

4. A method according to claim 1, wherein said step of feeding comprises feeding coating metal in liquid form into said inlet end of said passageway.

5. A method according to any preceding claim, wherein said metal core wire is of a metal selected from the group consisting of steel, copper, aluminium or alloys thereof and said coating metal is a metal selected from the group consisting of zinc, lead, tin or alloys thereof, in addition to the metals of said metal core wire.

6. A method according to claim 1, wherein said metal core wire comprises steel and said coating metal comprises a bar of aluminium, and further comprising preliminarily heating said steel wire to 250—350°C, and preliminarily heating said aluminium bar to 300—450°C.

7. A method according to any preceding claim, further comprising applying a forward traction force of 150—300 kg to said metal core wire during extrusion.

8. A method according to any preceding claim, wherein coating metal is passed into said chamber from two said passageways.

9. An apparatus for manufacturing a composite metal wire including a metal core wire surrounded by a coating metal of a material different from said metal core wire, said apparatus comprising:

a rotary wheel having therein a peripheral groove, a fixed shoe block having a fitting surface cooperating with a circumferential portion of said groove to define therewith a narrow passageway having an inlet end and an outlet end, a fixed stopper portion fitting in said groove to entirely close said passageway and to define said outlet end thereof, and a covering chamber communicating with said outlet end of said passageway having a nipple for guiding a metal core wire and a die for defining the outer cross-section of a composite metal wire, whereby:—

on feeding coating metal into said inlet end of said passageway, while rotating said rotary wheel in a direction toward said outlet end of said passageway, said coating metal is subjected within said passageway to plastic deformation due to oppositely directed frictional forces including a greater friction force from the surfaces of said wheel defining said groove and a lesser friction force from said fitting surface of said fixed shoe block, said coating metal is positively carried through said passageway by said greater friction force and causing said coating metal to collide with said fixed stopper portion, thereby imparting an extrusion pressure to said coating metal and, due to said extrusion pressure, said coating metal is passed into said chamber, thus filling said chamber with said coating metal;

and, on passing the metal core wire into said nipple and through said covering chamber said metal core wire is covered with said coating metal to form a bond therebetween, and can be extruded through said die said metal core wire covered with said coating metal as a composite metal wire.

10. An apparatus for manufacturing a composite metal wire according to claim 9, further comprising a second rotary wheel, the two of the rotatory wheels being symmetrically installed in a common plane.

11. An apparatus for manufacturing a composite metal wire according to claim 10, wherein a fixed shoe block is installed with a close fit in common to said two of the rotatory wheels.

12. An apparatus for manufacturing a composite metal wire according to claims 9 and 10, wherein the or each passageway is of a varying cross sectional area which decreases halfway and increases therefrom to the back thereof to provide frictional drag necessary for the pressure of extrusion and less consumption of power.

13. A method of manufacturing a composite metal wire substantially as hereinbefore described with reference to the accompanying drawings.

14. An apparatus for manufacturing a composite metal wire substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

For the Applicants,
CARPMAELS & RANSFORD,
Chartered Patent Agents,
43 Bloomsbury Square,
London, WC1A 2RA.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1981.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1584131 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

FIG. 1

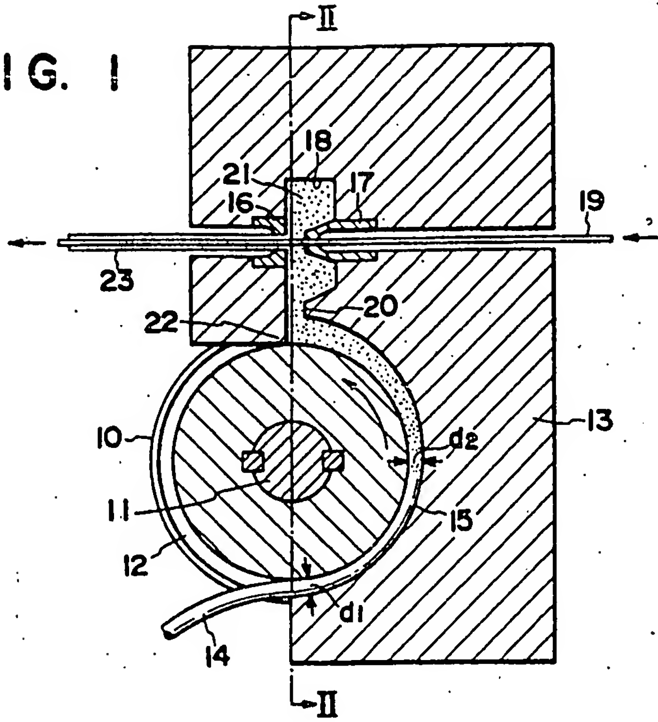
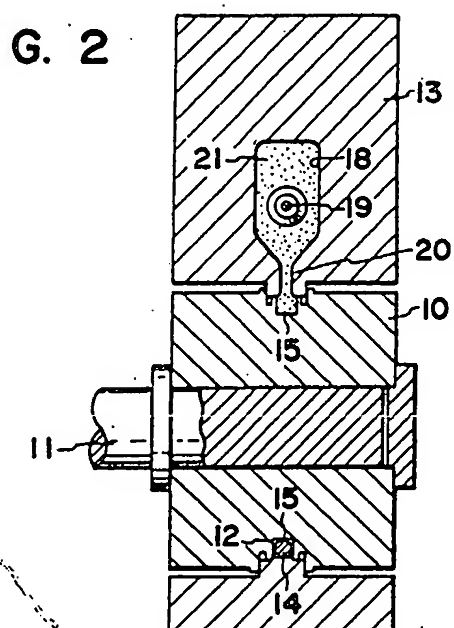


FIG. 2



1584131 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

FIG. 3

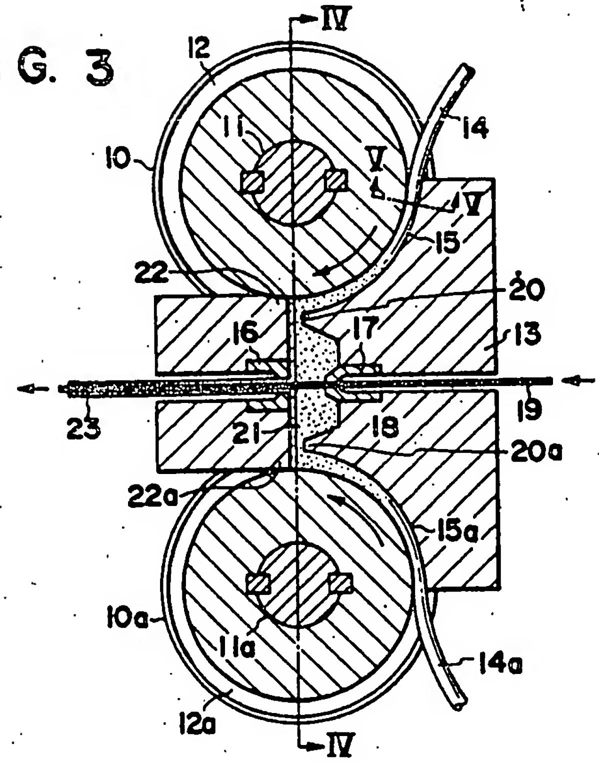


FIG. 4

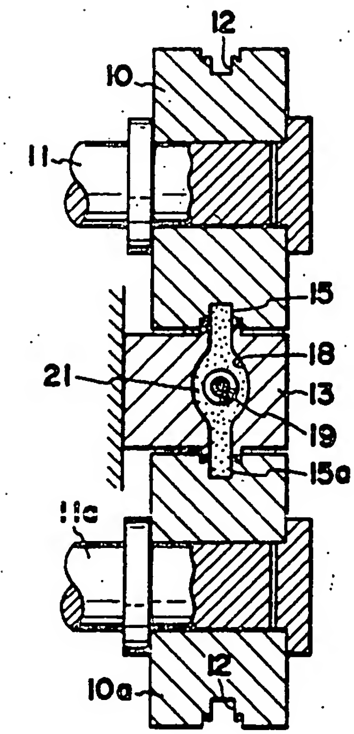


FIG. 5